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RELATION OF PREFERENTIAL MOTION AND OF THE SPECTRAL-CLASS AND MAGNITUDE VELOCITY PROGRESSIONS TO PROPER MOTION

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Communicated by E. B. Frost, May 28, 1917

This investigation concerned the relation between the preferential motion or streaming of the stars as interpreted by the ellipsoidal theory, and the size of proper motion.

It is based upon the radial velocities of Campbell's L. O. Catalogs[1] and Adams' Mt. Wilson Catalog,[2] a total of some 1800 stars. The stars, after being cleared of the effect of solarmotion, were divided into two classes according to size of proper motion, the 'large' ones being 0.″10 per year and over, while the 'small' ones are less than 0.″10, and into three classes by magnitude. The stars of Campbell's catalogs were divided into two groups, those of magnitude 2.9 and brighter and those of 3.0 to the limit of his catalogs which contain few stars fainter than 5½ magnitude. Adams' stars, with but few exceptions, are between magnitudes 5.5 and 6.5, and were treated separately as a third group.

Following the method of Kapteyn and Adams,[3] the radial velocities, without respect to sign, of the stars within 50° of the vertices of the ellipsoid were combined to represent the major axis of the ellipsoid which is designated by ρ_2. In a similar way those between 60° and 90° of the vertices were combined to represent the minor axis ρ_1.

The prolateness obtained for the stars of small μ of class F in Campbell's stars of 3.0 and fainter was 1.91. An examination showed that the average value of μ for these stars was considerably higher than for the other classes with small μ. The experiment was tried of limiting the proper motions of this group to 0.″05 which reduced the prolateness to 1.17. None of the other groups were so restricted in the matter of

size of proper motion. The results for the different spectral classes are given in table 1 where the numbers of stars in the groups are in parentheses.

TABLE 1

PROLATENESS FROM RADIAL VELOCITIES

ρ_2/ρ_1

SPECTRAL CLASS	CAMPBELL'S L. O CATALOGS				ADAMS' MT. WILSON CATALOG	
	2.9 and brighter		3.0 and fainter			
	Small μ	Large μ	Small μ	Large μ	Small μ	Large μ
B	(30) 1.81		(113) 0.96		(81) 0.82	
A			(127) 1.18	(31) 1.79	(110) 1.23	(9) 1.88
F			(38) 1.17	(126) 1.63	(18) 1.33	(11) 2.00
G			(81) 1.31	(41) 1.54	(55) 1.64	(29) 2.88
K			(226) 1.09	(124) 1.42		
M			(52) 1.19	(13) 1.96		
K, M	(20) 1.23	(18) 0.87			(84) 1.17	(31) 1.19
A, F, G	(18) 4.56	(25) 1.50				

With the exception of the K and M stars of Adams' catalog and those of 2.9 and brighter of the same classes in Campbell's catalogs, a consistently smaller prolateness is shown for the small than for the large proper motions. These exceptions may be only coincidences, but they require further investigation.

The underlying idea in this investigation was that the nearer stars (those of large μ and also the very bright stars) might be subject to different preferential motions from the more distant stars. This was indicated by anomalies in the position of the apex of solar motion yielded by 110 of the stars of magnitude 2.9 and brighter, and in the positions yielded by the different sizes of proper motion. It is to be noted that the 30 bright B stars show a large prolateness and are quite consistent for so small a group—half of the velocities in the regions of the vertices of the ellipsoid are larger than any in the regions at right angles to the axis. The large velocities are found in the region of both vertices. The indications that the very distant stars are not subject to preference of motion for the ellipsoidal axis furnishes a satisfactory explanation of the peculiar behavior of the class B stars.

A dissymmetry has been observed in the velocities of the A, F, and G stars of small μ north and south of the ellipsoidal axis which produces the effect of a considerable prolateness. It is in the nature of smaller average radial velocities for the northern stars than for other parts of the sky. If determinations of prolateness are confined to northern stars

only, values are obtained from the stars both of Campbell's and Adams' catalogs which are nearly the same as those yielded by the generally accepted constants of the ellipsoidal theory.

Evidence has been encountered in this investigation that the increases of radial velocity with spectral class and with decrease of brightness which have been observed, are in reality, largely at least, manifestations of the greater velocities which occur in the stars of large proper motion. When classified with respect to the size of proper motion and relation to the ellipsoidal axis, omitting a very few apparently exceptional velocities, these progressions disappear almost completely as will be seen from tables 2 and 3.

TABLE 2

ACCORDING TO SPECIAL CLASS*

(Small μ)

	ADAMS' MT. WILSON CATALOG			CAMBELL'S L. O. CATALOGS			
				3.0 and fainter		2.9 and brighter	
	ρ_2	ρ_1	Mean ρ	ρ_2	ρ_1	ρ_2	ρ_1
	km.	km.	km.	km.	km.	km.	km.
B.....	(52) 8.6	(29) 10.5	8.2	(60) 7.9	(53) 8.2	(16) 8.9	(14) 5.3
A.....	(49) 9.7	(55) 8.1	8.5	(56) 10.5	(60) 9.8		(3) 4.2
F.....	(6) 10.8	(10) 7.3	9.7	(18) 12.2	(18) 9.2	(4) 12.3	(3) 6.4
G.....	(23) 10.6	(29) 7.8	8.1	(44) 11.4	(32) 8.2		(3) 2.7
K.....	(25) 11.6	(24) 8.1	9.7	(80) 12.5	(120) 10.8	(6) 8.8	(8) 6.2
M.....	(11) 10.0	(13) 11.9	8.8	(13) 12.4	(28) 11.0	(2) 6.1	(1) 1.5

* Rejecting a few velocities of 30 km. and over.

TABLE 3

ACCORDING TO BRIGHTNESS*

	SMALL μ		LARGE μ			
	ρ_2	ρ_1	ρ_2	ρ_2'	ρ_1	ρ_1'
	km.	km.	km.	km.	km.	km.
2.9 and brighter....	(34) 13.5	(34) 6.2	(13) 15.9	54.8	(26) 13.6	35.8
3 to 5½.....	(297) 13.6	(317) 11.8	(96) 26.4	69.3	(212) 17.6	40.2
5½ to 6½.....	(179) 12.4	(169) 10.4	(31) 45.2	70.6	(49) 22.3	39.8

* Omitting two stars in each of the two groups of 2.9 and brighter large μ because of the excessive effect in such small groups of their proper motions. ρ_2' and ρ_1' have been reduced to proper motion unity to make them comparable in that respect.

The conclusion from this investigation that the phenomenon of preferential motion for the ellipsoidal axis is confined to the nearer stars, in connection with the relation between radial velocity and proper motion which has been found by Kapteyn and Adams[3] automatically

leads to the inference that the velocities of the nearer stars are greater than for the distant stars. Such a condition is confirmed by the velocities of 41 stars whose parallaxes have been observed to be 0."06 or over. Their average radial velocity is 26.9 km. (or 20.7 km. if we omit four stars with velocities of from 73 km. to 98 km.) whereas the average velocity of a large number of stars of similar magnitude and spectral class (including many stars of small μ) which are undoubtedly at a much greater average distance than the 41 stars, may be taken at 15 km. (or 10 km. if limited to small proper motion).

Conclusions.—1. The preference for motion in the direction of the ellipsoidal axis appears to be confined to the stars of larger proper motion and brighter than 3.0 magnitude in all of the spectral classes with the possible exception of K and M. The limit of proper motion below which little or no preference for the ellipsoidal axis is shown, appears to be about 0."05.

2. The increase in prolateness in the stars of large proper motion can be traced chiefly to the direction of the ellipsoidal axis.

3. This relation to proper motion furnishes a satisfactory explanation of the peculiar behavior of the stars of class B.

4. The radial velocities of the nearer stars are larger than those of the more distant stars.

5. When classified according to size of proper motion, and a few large motions are excluded, there is no certain increase in the radial velocities of the different spectral classes.

6. When the radial velocities are classified according to size of proper motion, there is no certain change with magnitude.

The details of this investigation will be published in the *Astrophysical Journal.*

[1] *Berkeley, Lick Obs., Univ. Cal. Bull.*, **6**, 1911, (108); **7**, 1913, (20, 113).
[2] *Pasadena, Contrib. Mt. Wilson, Solar Obs.*, No. 105.
[3] These PROCEEDINGS, **1**, 1915, (14).

GROWTH OF ISOLATED SPOROPHYTES OF ANTHOCEROS

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Communicated, June 19, 1917

In view of the speculations concerning the possible derivation of the ferns from Anthoceros-like forms, it seemed worth while to determine how far the sporophyte is capable of an independent existence when separated from the supporting gametophyte.

The highly developed photosynthetic tissues of the sporophyte of Anthoceros, and its long period of growth, due to the persistence of actively dividing cells at its base, suggest that if the sporophyte were able to absorb water directly, instead of through the mediation of the gametophyte, it might be possible for it to live and develop when separated from the gametophyte, and thus to simulate the behavior of the young fern-sporophyte.

Preliminary experiments were made in the spring of 1916, and more extended ones were made during the winter and spring of 1916–17.

While these experiments were of a somewhat tentative character, and by no means exhaustive, the results were sufficiently interesting to seem worthy of record.

The species chosen for experiment, *Anthoceros Pearsoni* Howe, is a common liverwort in the vicinity of Stanford University. Young sporophytes were noted during the autumn, and plants were brought in at intervals during the late autumn and winter. They were kept in a cool greenhouse where they grew luxuriantly and furnished abundant material for experiment.

The large foot of the sporophyte is so completely grown to the surrounding tissue of the gametophyte, that it is impossible to completely isolate the sporophyte without removing the foot. It was therefore necessary to cut away, as completely as possible, the gametophytic tissues, thus exposing the foot of the sporophyte.

In the first experiments, the isolated sporophytes were placed with the lower part in a nutritive solution (Knop's Solution) but this was not found to be satisfactory, as bacteria developed to such an extent as to quite envelop the submerged part of the sporophyte, whose growth was thus much interfered with, although in some cases they survived for a month or more.

Much more satisfactory results were obtained by planting in sterilized earth. Small flower-pots filled with earth were thoroughly sterilized, and after planting, the flower-pots were placed in vessels filled with boiled tap water, thus avoiding watering from above. Each pot was covered with a tumbler, and in this way the isolated sporophytes were kept in a healthy state for a surprisingly long time.

Sooner or later Oscillatoria and other algal growths appeared, but probably with proper care these might be pretty well eliminated.

For a short time, a slight increase in length was noted, but this was in no case very marked. The most striking effect of the transplanting was apparently a marked hastening of the spore formation. Most of the specimens selected had not yet begun to show spores, and the

young sporophyte throughout was a vivid green. After about a month, most of them showed the darkening of the apical region, indicating the presence of ripe spores, and this darkening soon extended downward until it embraced pretty nearly the whole sporophyte. An examination showed both spores and elaters to be apparently in no way different from those found in normal sporophytes. These spores were observed to germinate freely, and the young gametophytes produced from them were apparently entirely normal.

As it might be argued that the small amount of gametophytic tissue left adhering to the isolated sporophyte might be necessary for the absorption of water, experiments were made in which the sporophyte was pulled out of the calyptra, leaving the foot behind. Although the larger part of these footless sporophytes failed to survive, nevertheless, a number of them lived for two months or more, and behaved very much like the others.

The only case in which there was present anything suggesting a formation of roots from the foot, was one where the bottom of the foot had been exposed by cutting away the underlying tissue of the gametophyte, thus bringing the foot into direct contact with the soil. A couple of short outgrowths, of the superficial cells, resembling rhizoids, were seen, but they were too inconspicuous to be of any great importance. It is hoped that further investigations may furnish more positive results.

This much can be definitely stated. The young sporophyte of *Anthoceros Pearsoni*, separated from its association with the gametophyte, is capable of a limited growth in length, and is able to mature normal spores and elaters from the young sporogenous tissue.

The following data may be of interest.

The greatest elongation noted, after transplanting, was about 3 mm. In most cases it was less than this.

The first planting was made on November 28. Some of these sporophytes were still alive on March 13. The foot had rotted off, but the chromatophores in the upper part were still green, and normal ripe spores had developed.

In the later plantings, many of the sporophytes were still alive when the experiments were concluded, ranging from six weeks to two months from the time of planting.

On January 13, a number of sporophytes, deprived of the foot, and thus completely severed from the gametophyte, were planted. Some of these were still alive on March 15. The cells of the broken end were still alive, but there was no evidence of rhizoid formation. Ripe spores and elaters were developed, as in the other experiments.

THE MESA VERDE TYPES OF PUEBLOS

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Communicated, June 14, 1917

The excavation of a mound in the Mesa Verde National Park, Colorado, by the Smithsonian Institution, at the request of the Interior Department, during the summer of 1916, uncovered a building called Far View House belonging to a type which is morphologically the same as that of adjacent cliff dwellings. In form Far View House differs from its nearest large neighbor, Spruce Tree House; its outline is rectangular while that of a cliff dwelling, like Spruce Tree House, follows the irregular walls of the cave in which it lies. So close is its likeness in other points that we may say that the main difference between the two is that one is constructed in a cave sheltered by an overhanging roof, while the other is built under the open sky, without this protection; both are pure examples of the same type.

The importance of site has been magnified by some archæologists, and it must be confessed that the resemblance of the modern pueblo type to that of a cliff dwelling, is not very close. The accepted belief in an identity of cliff dweller and pueblo, largely determined by legendary and somatological evidences, is supported by architectural features of the Mesa Verde type, which is the purest form of pueblo construction. The former failure of house structure to adequately show this identity was due to the fact that modern pueblos belong to a mixed or highly modified type. Far View House is nearer in time as well as in form to the cliff dwelling, being unchanged by foreign influences. A comparison of it with typical cliff dwellings shows good evidences that community houses erected on sites so different are practically identical in details of construction and practically contemporaneous.

The type of pueblo illustrated by Far View House is now extinct and we have reason to believe that it antedated the beginning of the seventeenth century. It is therefore a true unmodified expression of the aboriginal mind, representing a stage in the development of southwestern architecture preceding the modern type.

The feature that distinguishes the community building of our southwest from other aboriginal dwellings north of Mexico is the arrangement of rooms in stories, one above the other. Of course in its simplest form it has but one story; the multistoried form is characteristic of the highest developed condition of the eastern or pueblo area. It is pronounced in the Mesa Verde type when there are two forms of rooms

structurally unlike and functionally different. Some of these rooms are circular, others rectangular; the former probably ceremonial, the latter secular, probably domiciles. Both kinds of rooms were closely crowded together in a compact mass, and were two or more stories high, the upper rooms having lateral entrances from the roofs of lower terraces; the ground floor chambers generally entered through the roofs. In its simplest form the Mesa Verde type has but one circular room, centrally placed, with rectangular chambers arranged about it. The inhabitants carried on most of their daily occupations on the terraces; the men used the circular rooms for assemblies and ceremonies.

In Far View House there are four of these circular rooms, one of which, the largest, is centrally placed; the rectangular rooms number about fifty. On the south side there is a rectangular court enclosed on three sides by a low wall. A few yards from the southeast angle there is a low mound, the site of the village burial place.

Geographically the Mesa Verde type is widely distributed; its center of distribution was the valley of the San Juan and its tributaries, canyons or mesas of Arizona, Colorado, Utah, and New Mexico. Examples of it are not only numerically most abundant in this region but also are the best constructed. The influence of the type extends far from its center of origin, becoming modified as the distance increases. It appears in the great communal houses of the Chaco Canyon in New Mexico and in the cliff dwellings of Canyon de Tsegi, or Chelly Canyon, in Arizona. The type occurs both isolated and in clustered forms, as at Mummy Lake on the Mesa Verde, and on the La Plata; or united in great consolidated communal buildings, as in the Chaco Canyon and elsewhere.

The position of the kiva in relation to other rooms is the most important feature that separates the Mesa Verde from the modern pueblo type. The main characteristic of the latter type is diffuseness in the arrangement of rooms as compared with the compactness of the northern or more ancient form. The rectangular rooms of the modern type are arranged in rows separated by passageways, concentrated into pyramids or more generally in rectangles enclosing courts. This relation of the circular room has sufficient importance to indicate distinct types; a difference which is still further emphasized if we compare the structure of the roofs and its supports, or the ventilation and other openings in the floors of the Mesa Verde and the modern types.

The modern pueblo type is marked by isolated circular kivas and house masses, as seen in modern pueblos still inhabited and in the historic ruins in that region. We find also, as at Sia and Jemez, and elsewhere, rectangular rooms united with others serving the same purpose.

Two explanations have been advanced to account for this condition: (1) The original external kivas were destroyed by the Spaniards, and secrecy sought by hiding the room used for rites among the rectangular rooms. (2) A habit of performing rites in rectangular chambers in the midst of other rooms has been introduced by foreign additions. The former explanation throws light on the absence of kivas in several Rio Grande pueblos.

From what is said above it appears that the chief structural feature used in separating the two types of pueblos, known as the Mesa Verde and the modern, is the relative position of the circular kiva. The construction of the walls and roofs of circular rooms of the two types is characteristic. To this last feature a few lines should be devoted. The two kinds of circular kivas are distinguished as follows: (1) Those with a vaulted roof indicated by the remains of pilasters on which roof beams were supported and still to be found, even if the roof itself is wanting; and (2) circular kivas the roofs of which were flat, the rafters extending across the top parallel with each other, resting not on pilasters, but on the edge of the wall.

The kivas of Far View House, as in the majority of the kivas of cliff houses in the Mesa Verde, had vaulted roofs; but a few kivas, like those of Cliff Palace, had flat roofs. Accompanying the vaulted roofed circular kivas of Far View House was an elaborate interior construction for supplying fresh air, called the ventilator and deflector. In the flat-roofed kiva these constructions take another form, a description of which would take me too far afield at this time.

Far View House is only one of several types of open-sky buildings on the plateau. There is another more distinctly related in form to cliff dwellings. I refer, of course, to the mysterious structure called Sun Temple, brought to light from a pile of stones by the Smithsonian Institution in the summer of 1915.

In Sun Temple there is a circular kiva surrounded by rooms in the annex, at the west end, but the rooms of the main building surround a central court in which are two isolated circular kivas; there is also a fourth kiva a few feet outside the wall near the southeast corner. In other words, this structure shows in one building a combination of the compact type and the type with separated kivas. In structural details the kivas of Sun Temple resemble the second or flat roofed circular rooms of cliff houses and towers, the distribution of which, in the San Juan culture area, is wider geographically than the vaulted roofed form of Far View House. Sun Temple is a type of its own and must be looked upon as a highly specialized building. The nearest approach to it,

in form, are the 'towers' widely scattered throughout the San Juan culture area, a type imperfectly investigated. Provisionally I will designate this type as the Sun Temple type. Should it, as suspected, turn out on renewed study to be morphologically identical with towers, the term 'tower type' would suffice for both. Awaiting this needed field work, we may summarize by pointing out provisionally that there are three types of prehistoric buildings that have been clearly recognized on the Mesa Verde: (1) The Mesa Verde type; (2) the Sun Temple type; and (3) the tower type. The cliff dwellings and Far View House belong to the first of these.

In order to bring out in clear relief the differences between these prehistoric types and the archaic historic, or modern type, the following statements may aid the student.

A few references may first be made to rectangular chambers commonly called kivas, used by some of the modern pueblos for ceremonial functions. These rooms are not morphologically the same as circular kivas, but rather secular rooms adapted for religious functions. Among the Hopi these rectangular rooms are free from the houses; among some other pueblos embedded in them. The theory that ceremonial rooms of rectangular form are derived from the circular forms is not accepted by the author, but it is recognized that certain clans who once used free circular kivas now use rectangular ones. Clans that used a rectangular kiva at one time were not always too conservative to adopt a circular one, as we see from the evidence given below.

The Hopi rectangular 'kivas'[2] are isolated from house masses in the same way as the circular kivas of the modern type. One of the Hopi pueblos, called Hano, is inhabited by Tewa clans that came from the Rio Grande about 1770. The forms of the kivas of Tewan ruins in their old houses in the east are unknown, but, like Hano, had isolated kivas. Another foreign pueblo, on the Hopi East Mesa, called Sitcomovi, settled by clans from Zuñi, also has two rectangular kivas, situated in its court, separated from the rows of houses. There are no isolated kivas in modern Zuñi.

Unfortunately kivas have not been definitely identified in Hopi ruins, except at Kükütcomo and in a ruin in the Oraibi 'Wash' which, unlike the modern, are circular. Some of the clans use secular square rooms surrounded by living rooms, others have rectangular kivas separated from these rooms; a choice of position ascribed to the configuration of their mesas. In a court of the Hopi ruin, called Payüpki, whose builders were Tanoans who fled from the Rio Grande region in the decade 1680–1690, Victor Mindeleff records two isolated kivas, the

ground plan of each of which was a rectangular form. The Payüpki people returned to the Rio Grande about 1750 and were settled in Sandia and Isleta, both of which now have circular kivas.

The settlements along the Little Colorado, abandoned about the middle of the eighteenth century, had no circular kivas, as far as known, and the same is true of the ancient Zuñi settlements. The present pueblo Zuñi is of comparatively modern construction and its buildings show a comparatively late modern type. The form of the ancient kivas of the Zuñi region and their situation relative to house masses has not been observed, or at least has not been recorded by archæologists. The ceremonial chambers of modern Zuñi are rectangular, surrounded by rooms, a position that may have been chosen for secrecy or may be survivals of those in the Little Colorado settlements, to which some of the old Zuñi towns were related. When excavations are made in the round Zuñi ruins circular kivas may be brought to light, for Mota Padilla appears to refer to a kiva in the middle of the court of a circular ruin called Tzibola (Cibola).

Our knowledge of the forms of building on the Mesa Verde before the development of the pure types above mentioned is vague. It is possible that the earliest houses were not built of stone or other durable material but were subterranean and separated from each other. From these primitive buildings the more advanced types later developed, under the influence of 'cavern' life.

It is important to record that in the area in which the Mummy Lake mounds are now found there are depressions below the general surface suggesting subterranean pits, as if indicative of prepuebloan people whose homes were underground. Like pits have been described at the La Plata pueblo by Mr. Earl Morris, and similar structures near the mouth of the Gila were recorded by the early Spanish travelers as inhabited at the end of the sixteenth century. Evidences are not wanting to support the theory that early inhabitants of the pueblo region not only inhabited caves in the sides of canyons, but also used depressions in the earth, covered with roofs on a level with the surface of the ground. The call is urgent for renewed exploration on the Mesa Verde to enlighten us on the sites and form of prepuebloan huts.

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] The name kiva is applied by the Hopi to these rectangular rooms. I find no record of similar rectangular isolated kivas among inhabited pueblos on the Rio Grande, although they are universal in Hopi.

A DETERMINATION OF THE RATIO OF THE SPECIFIC HEATS OF HYDROGEN AT 18° AND −190°C.

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Communicated by R. A. Millikan, June 26, 1917

For the purpose of this study of the ratio of the specific heats of hydrogen the Lummer and Pringsheim method has been adapted to a one liter flask with a precision comparable with the extreme precision it has given in large carboys. The method consists essentially in obtaining γ from observation of the cooling consequent upon small adiabatic expansions by way of the ideal gas equation

$$(p_1/p_2)^{\gamma-1} = (\theta_1/\theta_2)^{\gamma}.$$

The cooling was in this case measured by a thermal element of 0.001 inches copper and constantan wires, lightly brazed at the junction, which were introduced through glass tubes drawn out inside to fine capillaries and spread nearly to the diameter of the flask, the junction being carefully placed at the center. The thermal E.M.F. developed by the expansion was measured by a null method with a Wolff potentiometer, the galvanometer sensibility being such that an equilibrium temperature could be read to 0.0002°. Because of the finite heat capacity of the junction and the surgings incident to the expansion, it was necessary to observe the cooling at a constant interval of time after the expansion, the interval varying from 0.6 to 1.0 seconds in different series of observations. With a small container there is during this time a considerable inflow of heat to the thermojunction by conduction and convection and by radiation, the total inflow being a function of the time and the mounting of the individual junction. Since this inflow is also proportional to the cooling, the error due to it is eliminated by taking a series of observations for different excess pressures and plotting γ as a function of Δp atmosphere, (this must be linear for the expansions used, which did not exceed 0.04 atmosphere) and taking the limiting value of γ for $\Delta p = 0$ as the true γ.

The method was first tested for air with three different junctions which gave lines of quite different slopes, but intercepts

1.4014, 1.4019, and 1.4017.

To this value computed from the ideal gas equation must be added a correction for internal work, 0.0012, as obtained from either the Berthelot

or the Van der Waals equation of state (cf. Partington[3]). The final value 1.4029, is in close accordance with the three values which have been obtained by this method in carboys of 60 to 100 liters: Lummer and Pringsheim,[1] 1.4025; Moody[2] 1.4003; Partington,[3] 1.4032. (Moody's published value has been revised by the addition of the internal work correction and by the removal of the applied radiation correction since it was already included in the intercept.)

Data showing the same degree of uniformity were obtained in hydrogen with four different junctions, in two cases the same junctions as were tested in air. These gave respectively

1.4013, 1.4006, 1.4013, and 1.4017.

There being no theoretical correction in the case of hydrogen, the final value is 1.4012. This value, so closely, in accord with the kinetic theory, is contrary to the only previous evidence of weight, viz., 1.4084, the original determination by Lummer and Pringsheim, and 1.407 computed by Scheel and Heuse[4] from observations on C_p, which point to a quantum effect in hydrogen even at 18°.

The development of the method in a one liter flask opened the possibility of observation with a liquid air bath, at a temperature where determinations by Scheel and Heuse on C_p and by Eucken[5] on C_v have shown hydrogen to be virtually monatomic. By introducing a second low resistance potentiometer into the thermojunction circuit, it was found possible to make the thermometric arrangement quite as sensitive at −190° as at 18°, in spite of the fact that the thermal E.M.F. per degree is only about half as great. Observations are necessarily less precise because of the comparatively rapid change in temperature of the bath and the attendant difficulty in duplicating pressures. The final value of γ with the correction for departure from the ideal gas state added, 1.592 at a mean temperature of 82° A., is however probably correct to 0.005, and corroborates closely the work of Scheel and Heuse.

A full account of the work will appear in the *Physical Review*.

[1] Lummer and Pringsheim, *Ann. Physik, Leipzig*, **64**, (536).
[2] Moody, *Physic. Rev., Ithaca*, **34**, (275).
[3] Partington, *Physik. Zs., Leipzig*, **14**, (969).
[4] Scheel and Heuse, *Am. Physik, Leipzig*, **40**, (473).
[5] Eucken, *Berlin, Sitz Ber. Ak. Wiss.*, 1912, (141).

NOTE ON THE COEFFICIENT OF TOTAL RADIATION OF A UNIFORMLY HEATED ENCLOSURE

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Communicated by R. A. Millikan, June 25, 1917

In a recent communication[1] I gave an estimate of the probable value of the coefficient of total radiation of a uniformly heated enclosure, or 'black body' (Stefan-Bolzmann constant).

It was shown that by making corrections for atmospheric absorption, the data obtained by various observers were of the order of

$$\sigma = 5.7 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4}.$$

My own value was given as

$$\sigma = 5.72 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4}$$

It was obtained by applying a correction of 1.2% for losses by diffuse reflection from the receiver used in evaluating the radiant power in absolute measure. Nine receivers were used, some of which were covered with lamp black and some with platinum black.

During the past winter further consideration was given (1) to the correction for the loss of energy by diffuse reflection from the receiver and (2) to the question of atmospheric absorption.

In view of the important conclusions arrived at by Millikan[2] as to the value of this constant, as the result of his further investigations of the value of the electron e, it seemed of interest to record herewith recalculations and new experimental verifications of the data on the radiation constant, just mentioned.

In the recalculations a correction of 1.2% was applied for losses by reflection from receivers covered with lamp black (soot) and a correction of 1.7% for losses by reflection from the receivers covered with platinum black. These corrections were determined by direct experiment upon some of the receivers and by comparison of the surfaces of the other receivers with samples of lamp black whose reflection losses had been determined in a previous investigation.[3]

The recalculated value is

$$\sigma = 5.722 = 10^{-12} \pm 0.012 \text{ watt cm.}^{-2} \text{ deg.}^{-4}$$

which is practically the same as previously obtained.

The correction for atmospheric absorption of dry air was determined by observing the transmission through a brass tube 6 cm. in diameter

and 51 cm. long, the ends of which were covered with w ndows of clear rock salt. This tube was evacuated with an oil pump and then filled with air which had been passed through phosphorous pentoxide. It therefore contained carbon dioxide which causes a small amount of absorption.

The transmission was determined by noting a series of galvanometer deflections caused by black body radiation (800° C.) which was passed through the evacuated tube and focused upon a linear thermopile of bismuth-silver. Immediately thereafter a stopcock was opened and either dried or undried air was permitted to enter, under atmospheric pressure.

Using air containing 9.95 grams of water per cubic meter the absorption amounted to 0.9 %.

Using dry air, the average value of the absorption (3 series of measurements) was 0.09%; which is the magnitude of the errors of observation. In view of the fact that in the measurements of the radiation constant, the column of (dry) air was less than 50 cm. if any correction was to be applied it could hardly be greater than 0.1%.

Millikan's calculations of σ, on the basis of recent determinations of Planck's element of action, h, from photoelectric measurements, and from his redetermination of the electron, e, is $\sigma = 5.72 \times 10^{-12} \pm 0.034$ watt cm. $^{-2}$ deg. $^{-4}$, which is exactly the result I obtained by direct measurement. The only misgiving is that this coincidence is accidental. In conclusion it may therefore be stated that further experiments are in progress in which the whole radiometric apparatus is in a vacuum, the radiator being an enclosure surrounded by molten metal.

[1] Coblentz, W. W., *Washington, Bul. Bur. Standards*, 12, 1916, (533).
[2] Millikan, R. A., these PROCEEDINGS, 3, 1916, (231).
[3] Coblentz, W. W., *Washington, Bull. Bur. Standards*, 9, 1913, (283).

THE DEVELOPMENT OF A SOURCE FOR STANDARD WAVE-LENGTHS AND THE IMPORTANCE OF THEIR FUNDAMENTAL VALUES

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The determination of wave-lengths in International Units forms an important part of the working program of a large number of laboratories. The primary International Unit is the absolute wave-length of the red cadmium line.[1] The secondaries are referred individually to the primary

standard and are thus freed from the systematic errors of the Rowland system.

For the main purposes which the new wave-lengths should serve, namely, the comparison of the wave-lengths in cosmical and terrestial sources, the determination of the constants in series formulae, and the investigation of the effect of changed terrestial conditions, thestandard and derived lines should be accurately reproducible and their wave-lengths should represent what may be considered the fundamental or unperturbed vibration of the emitting centers. Recent work at this observatory has shown, however, that the 6 mm.–6 amp. iron arc adopted as the source for International Secondary Standards,[2] while fulfilling to a moderate degree the first condition, gives for large classes of lines wave-lengths vitiated by pole effect.[3]

The investigation has involved the development of a standard source from which under ordinary working conditions both reproducible and fundamental wave-lengths are obtainable. The methods followed and the tests applied in its development are given in a Contribution from Mount Wilson Solar Observatory where the investigation will be reported in full.

The presence of pole effect in the International arc was shown by direct comparison between its center and the center of the proposed or provisional standard and also by comparing the wave-lengths of the International Secondaries belonging to groups *c* and *d* with their wave-lengths obtained from the new standard by means of the interferometer. The two independent methods gave the same result, namely, a systematic error of +0.006 A in the International wave-lengths of the lines of these two groups.

The importance of this result lies in the systematic character and the magnitude of the error, which is of the order of sun-arc displacements upon which our intimate knowledge of solar conditions must depend. If the solar wave-lengths of such lines are compared with the published International values, the solar lines apparently shift to the violet; but when compared with wave-lengths representing the fundamental vibrations, the same lines are displaced to the red. Such comparisons have already led and must necessarily lead to mistaken interpretations of solar phenomena.[4] The normal behavior of the great majority of iron lines, the stable lines of groups *a* and *b* is displacement to the red in the solar spectrum, whatever form of arc is used as the source. When the International or the 6 mm.–6 amp. Pfund arc is used, the iron lines of groups *c* and *d* are displaced to the violet and those of group *e* abnormally to the red, but with the proposed source the lines of these groups yield

displacements of the same sign and order of magnitude as the stable lines of groups *a* and *b*.

Tests of recently published wave-lengths of calcium and manganese show that they are contaminated by the disturbing influence of pole effect and it appears probable that little of the new work in wave-length determination is sufficiently free from this influence to meet the more and more exacting demands of the present and immediate future, for high accuracy in wave-length measurement.

We recommend that light be taken from a narrow equatorial zone of a 4 to 5 fold enlarged image of an iron arc of the Pfund type 12 mm. long carrying a current of 5 amperes. With such an arc the exposure time for the region λ 5600 to the violet is not excessive; for the region, λ 5600 to λ 6000, it is somewhat long when very high dispersion is required; but in this region the International arc is entirely lacking in stable lines and no element yields a sufficient number of lines of good quality here; from λ 6000 to the red the International Secondaries belong to group *b*. They are free from perturbing influences and for them any form of iron arc may be used as the source.

To obtain dependable wave-lengths of other elements the necessary preliminary is an examination for pole effect. If it is found to be present, a method for its elimination should be worked out and applied before attempting the wave-length measurements. As the method of the elimination depends upon the element, the problem of wave-length determination is no longer one of mere routine but offers opportunities for a real investigation.

[1] *Smithsonian Physical Tables*, p. 172.

[2] *Trans. Int. Union Coöp. Solar Research*, **4**, (59).

[3] St. John, C. E., and Babcock, H. D., *Mt. Wilson Contrib.*, No. 106; *Astroph. J., Chicago*, **42**, 1915, (231–262).

[4] St. John, C. E., *Mt. Wilson Contrib.*, No. 123, pages 11 and 27; *Astroph. J., Chicago*, **44**, 1916, (311–341), pages 321 and 337.

ON THE PRESENCE OF ALBUMOSES IN EXTRACTS OF THE POSTERIOR LOBE OF THE HYPOPHYSIS CEREBRI

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Communicated July 2, 1917

In recent years some very definite statements have been made in respect to the chemical nature of the active principle or principles of the hypophysis cerebri (pituitary gland). Among the claims advanced none are more sharply defined than those published by H. Fühner[1] on

behalf of the chemists of the research laboratory of the Farbwerke-Hoechst Company.

From extracts of the posterior lobe of the hypophysis, which had been freed of coagulable proteids,[2] these investigators obtained a mixture of crystalline sulphates of high physiological activity which was quite unjustifiably named 'Hypophysin.' What misconceptions may arise in connection with the use of this term 'hypophysin'—a designation for an unknown number of substances—may be seen when we read in a treatise on organotherapy that "Hypophysin is the chemically active pure posterior pituitary hormone, marketed as a sulphate."[3]

Further research enabled the chemists referred to to separate their 'hypophysin' into four unnamed crystalline fractions which, in respect to physical and chemical properties, are easily distinguished, the one from the other. These fractions are described in the following words:

1. A colorless, well crystallized sulphate which easily dissolves in water with neutral reaction and is difficultly soluble in alcohol, acetone and ethyl acetate. It is optically active (laevo-rotatory, $[\alpha]_D = -54.02°$) and carbonizes without melting when heated to a high temperature. The Pauly and biuret reactions are positive. With picric acid this substance forms a salt difficultly soluble in water.

2. There was also obtained a substance yielding a well crystallized, colorless sulphate which dissolves in water with faint acid reaction and is likewise difficultly soluble in alcohol, acetone, ethyl acetate, etc. The optical rotatory power of this preparation is $[\alpha]_D = -27.17°$; it decomposes when heated to 198–200°C. and gives the Pauly and biuret reactions. Contrary to the substance described under (1) this compound forms a picrate easily soluble in water. If this substance is brought into contact with alkalies a volatile amine base is at once liberated.

3. A third substance was isolated in the form of a crystalline, faintly yellow sulphate which, to be sure, is present in only very small amount. It is easily soluble in water and methyl alcohol with faintly acid reaction, and difficultly soluble in absolute alcohol, acetone and ethyl acetate. It turns the plane of polarized light to the left; its rotatory power is $[\alpha]_D = -39.25°$. On heating the substance decomposes at 185–186°C. The Pauly and biuret reactions are positive. With picric acid is obtained a salt easily soluble in water.

4. The mother liquor remaining after the fractional precipitation of the three substances just described yields, on cautious evaporation in a vacuum, a brittle, glassy, hygroscopic mass which dissolves easily in water and methyl alcohol, with difficulty in ethyl acetate and acetone. The solution of this substance shows an optical rotatory power of $[\alpha]_D = -21.26°$ and gives the Pauly but not the biuret reaction. Recently it has been found possible to

isolate also from the mother liquors a yellow, crystalline, neutral substance which dissolves easily in water and alcohol, with difficulty in ether, acetone and ethyl acetate. The preparation in aqueous solution rotates the plane of polarized light to the right ($[\alpha]_D = +5.99°$) and gives neither the Pauly nor the biuret reaction. The decomposition temperature is 95 to 96°C. The preparation gives with picric acid a compound difficultly soluble in water.

'Hypophysin' (the mixture of substances) is stated by Führer to represent the physiological activity of the posterior lobe in respect to blood-pressure, respiration and uterine contractility and the sum of the actions of the four crystalline fractions equals that of the undifferentiated hypophysis.

Führer's conclusions as to the pharmacological action of the four fractions are as follows:[4]

Fraction 1 has only a slight action on the respiratory apparatus and the uterus, but shows the typical action of 'hypophysin' on blood-pressure.

Fraction 2 has a pronounced action (*ausgeprägte Wirkung*) on blood-pressure, on respiration and on the uterus.

Fraction 3 behaves qualitatively like fraction 2 but has a more marked stimulating action on the uterus.

Fraction 4 (mother liquor and crystalline part) has an action on the uterus equivalent to that of fraction 3 but only a very slight action on blood-pressure and on respiration.

From his experiments Führer draws the conclusion that the uterus-stimulating power of the hypophysis, which is, practically speaking, the most valuable property of extracts of the gland, resides, not in one, but in various (*verschiedene*) constituents of the organ, the condition being analogous to that found to hold for ergot.

From a chemical point of view, it is especially noteworthy that fractions 1, 2 and 3 give the biuret reaction as well as Pauly's reaction and that all three are laevo-rotatory; fraction 1, physiologically the least active, has the highest rotation, $[\alpha]_D = -54.02°$. It is easily demonstrated, we believe, that one or more albumoses (or polypeptids if the term is preferred) are present in the first three of these fractions and no doubt also in the fourth. We have found, as will be shown in a subsequent paper, that substances of the nature of albumoses can be isolated from many organs, It is these substances, which are themselves inactive, that give the biuret, the Pauly and other reactions of the so-called isolated principles and that account for their laevo-rotation.

The following analysis of one of the commercial preparations of the posterior lobe of the hypophysis is offered in support of our contention

that all those fractions of 'hypophysin' which give the biuret reaction contain albumose. The extract called 'Pituitrin' (Parke, Davis & Co.) was used first because it could be purchased in large quantities ($\frac{1}{2}$ oz. bottles).

The contents of 10 bottles, approximately 150 cc., were extracted three times with ether to remove a preservative (chloretone) and then concentrated under an electric fan on the water bath to a volume of 10 to 15 cc. A small amount of flocculent material which separated was removed by filtration, the filtrate was diluted with an equal volume of absolute alcohol and a solution of lead acetate was added, which induced a very slight precipitation. Addition of ammonia to faint alkalinity did not materially increase the precipitate, from which it was concluded that no appreciable amount of native proteid could be present, and that no advantage would accrue from the use of basic lead acetate, as in the procedure which will be described in a subsequent paper. An albumose, especially if of secondary nature, would escape precipitation by ammoniacal lead acetate. The alcoholic filtrate was freed from lead with sulphuric acid and the filtrate from the lead sulphate was concentrated to a small volume (a few cc.) and treated with an equal volume of saturated ammonium sulphate solution. The resulting flocculent precipitate, which was not very abundant, was washed with half-saturated ammonium sulphate solution, dried *in vacuo*, dissolved in water and again precipitated with an equal volume of saturated ammonium sulphate solution. The precipitate was again washed with half-saturated ammonium sulphate solution and treated with an excess of barium hydroxide. After filtering off the barium sulphate, the filtrate was heated on the water bath until all the ammonia had been expelled and the excess of barium was removed with sulphuric acid. The filtered solution was then concentrated to a very small volume and dropped into absolute alcohol, ether being added until no further precipitation was produced. The substance here thrown out, which was small in bulk (0.010 g.), was of less interest to us than the fraction presently to be described. It gave the Millon and biuret reactions, as well as that of Pauly. Knoop's reaction for histidine was negative.

The filtrate from the half-saturation with ammonium sulphate as described above was saturated with finely powdered ammonium sulphate, which caused the appearance of a gummy precipitate so characteristic of albumoses when treated in this manner. The precipitate was filtered off, washed with saturated ammonium sulphate solution, dissolved in water and treated with barium hydroxide in the usual manner. The solution, freed from ammonia and the excess of barium, was concentrated to a very small volume and dropped into absolute alcohol, the precipitation being completed with ether. The substance thus thrown out was collected as completely as possible and dried *in vacuo;* 0.031 g. in 1 cc. of water in a 0.5 dcm. tube showed a rotation of $-1.38°$, whence $[\alpha]_D = -89°$. When the substance was reprecipitated with hot absolute alcohol its specific rotation was found to be $[\alpha]_D = -77.6°$.

As to its properties, the substance must be classed with the secondary albumoses. It has been shown to be precipitated by saturation of its solution with ammonium sulphate. It is non-coagulable on boiling, gives the biuret reaction (hemi-biuret) very beautifully, as also Pauly's reaction, while Knoop's bromine reaction for histidine is entirely negative. This negative result with Knoop's reagent excludes the presence of histidine as an admixture in our substance.[5] Picric acid added to an aqueous solution gives a precipitate. The addition of Millon's reagent gave rise to a slight turbidity, but on boiling the characteristic red color was not obtainable. In this respect there was entire agreement with a secondary albumose which we have isolated from the mucosa of the small intestine. The ninhydrin reaction was positive when made in the usual manner but we are confident that this is due to the fact that adherent amino acids were not entirely removed. To do this would have required several reprecipitations with ammonium sulphate.

The albumose here described was found to have a quite negligible action when tested with the virgin cat's uterus.

A secondary albumose which was prepared by digesting fresh thyroid glands of the pig behaved in every respect like the above substance. Its specific rotation was found to be $[\alpha]_D = -88.1°$, while that of the pituitary albumose varies from $-78°$ to $-89°$.

We come now to the filtrate from the complete salting out with ammonium sulphate. This was freed from ammonium sulphate in the usual manner. Reduced to a small volume, the solution was dropped into absolute alcohol, the precipitation being completed with ether as with the preceding substances. The material thus obtained was readily soluble in water and gave the usual response of pituitary extracts when tested on the isolated uterus of the virgin guinea pig. It also still gave the Pauly and the biuret reactions, though with greatly lessened intensity as compared with the original solution. It fails to give Knoop's reaction for histidine so that we must conclude that this amino acid does not exist as such in any considerable amounts, if at all, in pituitary extracts. The rotation of 0.0381 g. in 1 cc. of water in a 0.5 dcm. tube was found to be $-0.52°$, from which $[\alpha]_D = -27.4°$. We have here a substance which may be compared with respect to physiological activity, rotation and chemical tests with Führer's 'hypophysin' fractions 2 and 3. The solution used in the polarizing tests was saturated with powdered ammonium sulphate and again the characteristic precipitate of albumose was produced, though, naturally, it was not abundant this time. Evidently we have here the remnant of albumose which remained in solution after the first saturation with ammonium sulphate. If we were to apply this salting out to larger quantities of pituitary extract it is possible that more or less of a true peptone would be found in the filtrate. Certainly, there always remains in the filtrate, even after two

saturations, a substance which gives a pink biuret reaction. Only more extended research can show to what extent this is albumose and to what extent peptone.

We believe that there is no mystery attaching to the constituents of pituitary extracts that have been shown to give positive Pauly and biuret reactions *and a negative Knoop's bromine reaction.* These constituents must be classed as albumoses (and even peptones) and the German chemists are to be congratulated if they have obtained them in the form of physiologically active crystalline sulphates, as has been stated on their behalf by Führer, even though they have failed to recognize their proteid nature.

We have made qualitative tests with other commercial pituitary extracts (Armour's Pituitary Liquid, and Solution Pituitary Extract, Mulford) and have found, as was to be expected, that albumoses can be salted out from all of them. The amount of proteid material present varies considerably in these preparations—one of them (Armour's Pituitary Liquid) appears to have only a trace of that form of proteid (coagulable proteid plus primary albumoses) which gives a precipitate with potassium ferrocyanide and acetic acid and to have practically all its biuret-yielding substance in the form of secondary albumose.

As to the total amount of biuret-yielding material present in the extract analyzed—and by this we mean the substance or substances that give the biuret reaction *immediately at room temperature* (and not, as histidine gives it, after heating)—we believe that we are close to the truth when we say that it cannot be far below 10% in weight of the total solid matter. The dry residue from five bottles of extract (73 cc.), exclusive of chloretone, was found to be 0.415 g. The amount of albumose, primary (?) and secondary, recovered from ten bottles (in the analysis described above), with a dry residue of 0.830 g., was approximately 0.050 g. The losses, at a conservative estimate, could hardly have been less than 0.025 to 0.030 g. On this basis we should have had, in the specimen analyzed, close to 10% of biuret-yielding material.

It may be of interest to state here that when the dry residue of five bottles (0.415 g.) *was heated in a boiling water bath for one hour in 10 cc. of 25% hydrochloric acid the biuret reaction*[6] *disappeared entirely* but the Pauly reaction for histidine was still obtained. The disappearance of the biuret reaction after boiling with hydrochloric acid can only be interpreted as due to hydrolysis of our albumose.

After having completed our examination of the American pituitary preparations we learned that the 'hypophysin' of the Hoechst chemists could be ob-

tained in this country. We accordingly purchased two hundred 1 cc. ampullæ of this product, which is described on the labels as a "sterile solution, 1:1000, of the isolated active substances from the glandula pituitaria." We did not inquire if a preservative is used in its preparation, as the presence of a substance of this character would hardly interfere with the isolation of a proteose.

The residue from ten ampulles, as obtained by evaporation at a low water-bath temperature under an electric fan and subsequent drying over sulphuric acid, amounted to 0.0154 g. The dry residue from the two hundred 1 cc. ampulles would therefore have weighed 0.3080 g. One hundred and ninety cubic centimeters, that is to say, the total quantity of solution with the exception of the 10 cc. used for the estimation of the dry residue, were concentrated on the water bath under the fan to a volume of 2.5 cc.[7] and saturated with finely powdered ammonium sulphate. The characteristic gummy precipitate of salted-out albumose immediately collected on the stirring rod and on the sides of the tube containing the solution. The precipitate was washed with saturated ammonium sulphate solution, decomposed with barium hydroxide and the freed albumose was precipitated as a "sulphate" with absolute alcohol and ether in the manner already described. Dried over sulphuric acid, the albumose thus obtained weighed 0.017 g. The reactions were those already described—a beautiful pink biuret, a positive Pauly and a negative Knoop reaction. Potassium ferrocyanide and acetic acid also failed to give a precipitate, showing that coagulable proteids and primary albumoses were not present.

The ammonium sulphate filtrate from the gummy albumose precipitate still gave a fine pink biuret reaction, as was the case also with all the American preparations under the same conditions. The addition of a drop or two of a very concentrated solution of trichloracetic acid to this filtrate caused an immediate precipitation of gummy droplets. These give the biuret reaction with great intensity and represent a further yield of albumose with a probable admixture of peptone and traces of other substances. It may be stated in this connection that the ammonium sulphate filtrates of our American preparations also give with trichloracetic acid a precipitate which is indistinguishable in its reaction from that obtained with hypophysin. A certain amount of albumose or peptone still remains in these ammonium sulphate filtrates even after the use of trichloracetic acid.

The Hoechst preparation is no doubt a clean product and certainly contains less dry residue than the products prepared in this country. We have seen that the dry residue of ten 1 cc. ampulles of hypophysin was 0.0154 g. The dry residue of ten 1 cc. ampulles of Armour's Pituitary Liquid was 0.0242 g. and in its relatively smaller content in proteoses this prepration more nearly approaches hypophysin than any other examined by us. It is to be understood that we are not criticizing these products because they happen to contain more or less albumose.

This in itself is of no consequence, as this albumose does not appear to be toxic.

The points that we wish to emphasize are these:

1. Carefully prepared commercial extracts of the posterior lobe of the hypophysis contain albumoses.

2. Hypophysin, stated to be a mixture of the "isolated active substances of the pituitary gland," is likewise contaminated with albumoses.

3. All claims in respect to the isolation of pure principles, as made by the Hoechst chemists, must be looked upon, in view of our findings, as being without foundation.

Other considerations also lend support to the last statement.

One who is familiar with the high activity for the virgin uterus of fresh extracts of the hypophysis can only agree with Fenger when he asserts that the as yet unknown constituent of this gland which affects the uterus so powerfully cannot be less potent than β–imidoazolylethylamine, and may be even more powerful. Fenger says that an acidulated methyl alcohol extract of the posterior lobe of the hypophysis, for which no claim to chemical purity can be advanced, "showed a uterine-contracting power somewhat stronger than pure β–I."[4] If we examine the tracings given by Führer in his experiments with the Hoechst products, experiments in which quantities varying from 0.05 to 0.5 mgm. were tested on the guinea pig's uterus in a 100 cc. bath of Locke's solution, it will be seen that these products are much weaker than β–imidoazolylethylamine. Here again is evidence that the crystalline salts of the Hoechst chemists represent mixtures of active and inactive principles and not pure chemical individuals.

Further evidence that Hypophysin does not consist of chemically pure principles is given by the pharmacological tests made with it in this laboratory. Dr. D. I. Macht has kindly compared the oxytocic strength of the preparation with that of Armour's Pituitary Liquid, this having been selected from among the American products because it most nearly approaches Hypophysin in respect to dry matter and a low albumose content. He reports that the Armour product, which makes no pretense of being a pure chemical principle, is "several times more powerful in its action on the virgin uterus of the guinea pig than Hypophysin." There is no reason to assume that the Hypophysin used in Dr. Macht's tests had lost any of its original strength as the labels on the packages give no hint of instability or loss of strength with time.

The question naturally arises whether the albumose or other proteose here shown to be present in all active pituitary extracts is not itself the uterine stimulant. The secondary albumose which was isolated by us

from "Pituitrin" was practically devoid of an oxytocic action, as has already been stated. Investigations on the bio-chemistry of the intestinal and gastric mucosa which we hope soon to publish also lend no support to the theory that pituitary extracts contain an active albumose. We have prepared a water-soluble powder from this mucosa which is highly active for the guinea pig's uterus (1:1,000,000) and for the intestinal strip (1:250,000), which induces a distinct rise of blood-pressure in the cat, and which in respect to its chemical reactions, its behavior towards ammonium sulphate and polarized light, *is indistinguishable from a diluted pituitary extract.* The similar behavior in these several respects of gastric and intestinal 'motiline' solutions and pituitary extracts first led us to suspect that these latter also contain albumoses. Now, in the case of these intestinal preparations, we have had sufficient material on hand for the application of purification processes. *We finally emerged with a secondary albumose which was entirely devoid of oxytocic, pressor, depressor or secretory action.* It is this experience, together with our discovery than an inactive albumose can be prepared from the ordinary pituitary extracts, as already stated, which fortifies us in our belief that the proteoses of the gland have nothing whatever to do with the physiological activity of the organ.

It is not our purpose to consider here the literature[6] pertaining to the 'peristaltic hormones' that are known to occur in almost all, if not all, organs of the body, It is worthy of note, however, that an extract of the gastric or intestinal mucosa can be prepared, as we have already stated, which has a pressor action for the circulation and a marked oxytocic power in a concentration of 1:1,000,000. This powerful action points strongly to the conclusion that here also, as in the case of pituitary extracts, we are dealing with a motiline which, in a state of chemical purity, would be fully as active as β–imidoazolylethylamine. And this again leads us to the supposition that the oxytocic principle (or motiline) of the hypophysis is not a hormone or substance specific to this organ, but is rather a widely distributed substance, everywhere the same, which may have its origin in the various tissues, in the gastric or intestinal mucosa, or which may be absorbed as such from among the products of digestion. We hope that our discovery of the contaminating and difficultly separable proteoses in physiologically active extracts will pave the way to the solution of these problems.

We cannot conclude this communication without adding a few words in regard to the presence of proteoses in the various tissues of the body. Proof of their existence in pituitary extracts has been given and reference has been made to their presence in gastric and intestinal extracts. By

the use of certain methods which will shortly be described in detail we have found that a secondary albumose (to name only a single proteose which is sharply differentiated from all native proteids and primary proteoses) can be isolated in small amounts from all of the cellular tissues of the body thus far examined. Skeletal muscle appears to contain albumose in the smallest amount, gastric and intestinal mucosa contain it even after four days' starvation, *much more during digestion of a meat meal*, while organs like the thyroid gland contain much more, weight for weight, than skeletal muscle. We have not as yet been able to isolate definitely a true proteose of any sort from the plasma of the blood, though able to show that the cellular elements of the blood yield a readily demonstrable amount of albúmose.

It was not originally our purpose to study these proteoses or to isolate them from the various tissues, but finding them always present in our final products whenever we attempted to isolate certain 'hormones,' such as the intestinal motiline and secretine, even when our methods of treating the tissues could not have produced them, we were forced to undertake a study of methods for their separation from the hormones. A future communication in these PROCEEDINGS will deal with this question.

Conclusions—1. Secondary albumoses and possibly peptones (or polypeptids if the term is preferred) were found to be present in all of the therapeutically used extracts of the posterior lobe of the hypophysis cerebri that were examined. To what extent the proteose content of the gland may have been increased by autolysis or by processes incidental to the manufacture of the extracts it is impossible for us to state. We believe, nevertheless, that the perfectly fresh, bloodless glands yield proteoses, inasmuch as we have actually isolated such substances from the thyroid gland and other organs when taken from the animal immediately after bleeding it to death.

2. The 'Hypophysin' of the Farbwerke-Hoechst Company is not, as claimed for it, "a solution of the isolated active substances of the pituitary gland" but a mixture of albumoses (and possibly peptones) with varying and unknown amounts of active and inactive constituents of the gland. The albumoses present in 'Hypophysin' account fully for the chemical reactions (such as the biuret and the Pauly reactions and the left-handed rotation) which are stated to characterize the pretended active principles. The albumoses as separated from pituitary extracts are devoid of action upon the uterus. In view of the facts here presented it must be evident that the active principles of the hypophysis cerebri have not yet been isolated as chemical individuals.

[1] Fühner, H., *Zs. ges. exp. Medizin, Berlin*, **1**, 1913, (397).

[2] "Vollständig von Eiweiss befreite Auszüge aus den Hinterlappen von Rinderhypophysen." Fühner, *loc. cit.*, p. 399.

[3] Harrower, H. R., *Practical Hormone Therapy*, New York, 1914, p. 460. A Glossary of Terms.

[4] Fühner, *loc cit.*, p. 443.

[5] Cf. Aldrich, T. B., *J. Amer. Chem. Soc., Easton, Pa.*, **38**, 1915, (203).

[6] The biuret reaction was made at room temperature. Unfortunately we did not apply heat as is done when making this test for histidine. This substance was no doubt present, having been set free from the albumoses by hydrolysis, as is shown by the positive Pauly test.

[7] This also contained the redissolved residue from the 10 cc. used for the estimation of dry matter.

[8] Fenger, F., *J. Biol. Chem., Baltimore*, **25**, 1916, (417).

[9] Cf. Ott, Enriquez and Hallion, Zuelzer, Weiland, Köhler and others.

ON THE RÔLE OF THE THYMUS IN THE PRODUCTION OF TETANY

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In a number of experiments on larvae of *Amblystoma punctatum* and *A. opacum* the influence of thymus was studied. It was found that the effect of thymus upon these animals is not exactly similar to its effect on tadpoles of frogs or toads. With regard to this difference the most conspicuous and important effect of the thymus feeding in Salamander larvae is the occurrence of severe tetany in the thymus-fed larvae.

Up to the present, 67 specimens of *A. punctatum* and *A. opacum* were fed exclusively on Thymus after they had reached an age of about six to fourteen days. In each single individual tetany was produced.

For several days previous to the occurrence of the acute attacks, the animals are less active and their appetite is diminished. The acute stage appears in two forms: a mild form and a severe form. The mild form manifests itself by clonic convulsions of the hind limbs and the tail, while the severe form consists in clonic convulsions of the entire system of muscles. In the beginning of the tetany period, the attacks exhibit the characteristics of the mild form, then become severe and towards the end of the entire period again are mild. Each acute attack is followed by a tonic spasm of the entire body, during which the body is stiff for a short time. After several acute attacks the hind limbs become permanently twisted and stiffened and are to some extent paralyzed. Later on the forelegs and in severe cases even the neck and spinal cord become paralyzed.

The severity depends to a great extent on the temperature in which the animals are kept. In low temperature the acute tetany begins later and is of shorter duration than in high temperature In high temperature some animals succumb from the attacks; those which survive metamorphosis never show a complete recovery. In low temperature recovery may be complete and the animals can live after metamorphosis for many months and reach an age of at least fourteen months, even if they are kept on exclusive thymus diet after metamorphosis.

It should be particularly emphasized that no matter in what temperature the animals are kept, acute attacks cease a short time before metamorphosis and never occur in metamorphosed animals.

The symptoms of the attacks caused by thymus in the larvae of *A. punctatum* and *A. opacum* are the same as in the attacks observed in mammals after parathyroidectomy and the theory that they are caused by the same agent as *Tetania thyreopriva* suggests itself.

It would seem then, that thymus contains the substances which cause tetany and excretes them into the body, from which they are removed by the parathyroids. Extirpation of the latter would thus cause tetany.

If this is true, we should expect that thymus-feeding would produce tetany only in such species as have no parathyroids. In fact tetany in thymus-fed tadpoles has never been reported; these animals develop the parathyroids several days after hatching. The Salamander larvae however, have no parathyroids and the occurrence of tetany in thymus-fed larvae of that species corresponds with our expectations.

Furthermore, according to such a theory, thymus-fed animals which suffer from tetany should become free from it as soon as they develop parathyroids. The Salamanders develop parathyroids when they go into metamorphosis, which is actually the time that acute tetany ceased in our larvae.

Although many experiments must still be made to clear the entire problem—some of which are already in progress—for the present, the above theory might be valuable as a working hypothesis.

EVIDENCE OF ASSORTIVE MATING IN A NUDIBRANCH

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Communicated by E. L. Mark, June 11, 1917

In man there is found, according to Pearson and others, a slight but appreciable degree of positive correlation between the members of mating pairs as regards their stature and certain other characters. For Paramecium a similar, but higher, correlation was proved by Pearl (1907) to exist between the lengths of members of conjugating pairs. Jennings (1911) substantiated Pearl's discovery that in Paramecium large individuals are usually found mated with large, small individuals with small, and made more certain the conclusion that this correlation (homogamy) is due to real assortive mating, as Pearl had previously maintained.

This matter of assortive mating, which may have various important implications for evolution, appears not to have been studied in animals other than Paramecium and man. With reference to characters concerning the size of the organism, at least, it should, of course, be possible for assortive mating to take place only when there is available some physical basis for the required process of selection. Hence, although echinoderms and some other marine animals appear to congregate at their times of breeding, and may even be conspicuously disposed in pairs (Orton), it is not to be expected that invertebrates practicing external fertilization would, in general, yield any evidence of assortive mating. Among gastropods, however, the case is different, and notably so with nudibranchs. In the latter animals, which are hermaphroditic, a true copulation of two individuals seems a prerequisite for fertilization of the eggs. In some nudibranchs the male and female genital openings, two or three in number, situated on the right side of the body, are separated by a considerable distance, and the behavior of the animals in copulation shows that it is necessary for the 'male' and 'female' openings of one individual to be brought simultaneously into close relation with the appropriate openings of another (e.g., in Cenia, as described by Pelseneer, 1899).

Other nudibranchs, such as chromodorids, have the reproductive openings concentrated upon a single small papilla; but, in some cases, at least, their behavior during the maneuvers preliminary to actual copulation strongly suggests that here also there is a rather well-defined, though not absolute, mechanical necessity for equality in the sizes of

the individuals forming a successful mating pair. Reciprocal fertilization may be presumed to occur in most of these cases, and is certainly carried out in some instances.

The observation of mating pairs of Chromodoris zebra repeatedly suggested that under natural conditions this species forms copulating pairs of which the individual components closely correspond with each other in general size. Sexually mature specimens of this species range in length from 4 to 18 cm. Differences in the relative sizes of the various individuals are readily detected by the eye, while other dimensions of the animals may be subjected to measurement in the living condition.

One hundred and forty-eight pairs of copulating C. zebra were obtained in the field. The total length (anterior edge of the mantle to posterior termination of the foot) was determined for each specimen, according to a method[2] giving results sufficiently reproduceable for the purposes of statistical treatment. As a check upon this measurement certain other dimensions were ascertained, including the weight and the volume. Each of the methods of evaluating size yields the same qualitative result. Therefore the estimations of total length according to the procedure employed may be relied upon as a criterion of assortive mating with respect to size. In figures 1 and 2, summarizing the observations upon mating pairs, total length measurements are used.

Figure 1 is a regression plot showing the correlation between the lengths of individuals and the average lengths of their mates, as found under natural circumstances. If the correlation were perfect, the observed points would lie upon line "(1)"; if no correlation were to be detected the regression line "(2)" would coincide with m–m'; actually the degree of correlation between the lengths of individuals composing copulating pairs is of about the same magnitude as that found in cultures of Paramecium containing a mixture of pure lines.

Laboratory experiments were carried out with over 400 specimens, embracing about 200 individuals originally obtained in pairs, and an approximately equal number of "single" nudibranchs. About 50 specimens, ranging in length from 4 or 6 to 16 or 18 cm., were placed in each of a number of 9-gallon aquaria supplied with running water. After two days the mating pairs noted in each aquarium were removed, and measured. Data were in this way obtained from 119 pairs, which had come together under such purposely contrived circumstances that true random mating might easily take place, since so many individuals were crowded together in a small space; while if assortive mating is in any degree a real condition of copulation it should still make its influ-

ence sufficiently evident. Measurements of these pairs are plotted in figure 2. The correlation between the members of mating pairs is in fact better than in the previous case (fig. 1); reasons for this will be discussed in a subsequent paper.

A study of the behavior of Chromodoris supports the view that there is exercised an active selection of mating partners. As a rule, two animals greatly differing in size do not successfully copulate. This has

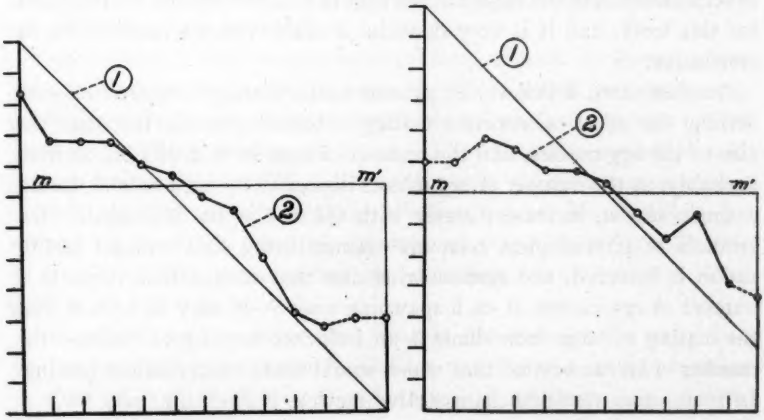

Fig. 1 Fig. 2

FIG. 1.—ILLUSTRATING THE CORRELATION IN SIZE BETWEEN THE MEMBERS OF 148 PAIRS OF CHROMODORIS ZEBRA COLLECTED IN THE FIELD

The thin continuous line (1) gives the lengths (as ordinates) for the different classes of individuals in order of decreasing size. The heavy line (2) gives the average lengths of the mates of the individuals of these classes. The unit is 1 cm; m—m' is the mean for all.

FIG. 2.—ILLUSTRATING THE CORRELATION IN SIZE BETWEEN THE MEMBERS OF 119 PAIRS OBTAINED IN LABORATORY EXPERIMENTS

The thin continuous line (1) gives the lengths (as ordinates) for the different classes of individuals in order of decreasing size. The heavy line (2) gives the average lengths of the mates of these classes. The unit is 1 cm; m—m' is the mean for all.

been verified by experiments in which the size of some individuals has been artificially reduced through starvation. The physical basis of assortive mating in Chromodoris is probably found in the relative attitudes assumed by the conjugants and in reactions to tactile (and chemical?) stimuli which determine these attitudes.

Two suggestions may be made regarding the possible significance of

assortive mating in Chromodoris. If the population is composed of a mixture of pure lines, then one effect of this type of copulation may well be, as in Paramecium (Jennings), the prevention of interlinear crossing. Certain generally accepted ideas regarding the life history of nudibranchs may tend to favor this view. The evidence for the presence of pure lines in the Chromodoris stock is, however, entirely inferential. It would, indeed, be almost impossible to obtain good evidence upon this point, unless, possibly, through a study of the rate of segmentation of the eggs; but the eggs of C. zebra are not well adapted for this work, and it is very doubtful if such evidence could be made conclusive.

Another, and, I believe, at present better founded, suggestion concerning the effect of assortive mating is based upon the fact that the size of the egg-masses, and the number of eggs in each ribbon, as well, probably, as the number of egg masses deposited by each animal during a single season, increase directly with the size of the individual. On grounds of physiological economy—remembering that mutual fertilization is involved, and remembering also that each animal deposits a number of egg-masses at each spawning season—it may be argued that the mating of large individuals is an influence tending to increase the number of larvae beyond that which would result from random pairing. In some other nudibranchs assortive mating, if it occurs, may have a different, or an additional, significance.

Summary.—Mating pairs of the nudibranch Chromodoris zebra are found to exhibit a rather high degree of correlation between the sizes of the two members. This is due to assortive mating, which may constitute an important influence tending to increase the numbers of larvae.

[1] Contributions from the Bermuda Biological Station for Research, No. 70.

[2] It was necessary to remove the animals from the water and place them, dorsal surface downward, upon a glass plate.

CORAL REEFS OF TUTUILA, WITH REFERENCE TO THE MURRAY AGASSIZ SOLUTION THEORY

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Communicated June, 22, 1917

Tutuila, Samoa, is a purely volcanic island without elevated coral reefs or limestones. It is surrounded by a recent fringing reef which forms a mere veneer over the modern off-shore marine platform, and extends a short distance seaward, its precipitous outer edge being from

5 to about 20 fathoms deep. In former times, the island may have been submerged about 20 fathoms below its present level, this being suggested by the fairly uniform depth of about 20 fathoms off the mouths of the harbors of the northern coast, while these harbors themselves have the appearance of drowned valleys.

However this may be, the latest movement of the island has been an emergence of about 8 feet above present high-tide level; for a platform about 8 feet above high tide juts out to seaward from the base of practically every promontory. The shores are strongly cliffed, some of the sea-cliffs being 500 feet high.

Being volcanic and densely forested from summit to shore, it was thought that rain-water falling upon the island might become so augmented in acidity as to dissolve the shoreward parts of the surrounding coral reef. This, however, is untrue. The rain-water is indeed acid, ranging from 0.126 to 0.678 $\times 10^{-5}$. However, the streams and springs of the island are usually slightly *alkaline*, due to bicarbonates; the average of 11 of the principal streams and 6 springs being 7.19 PH., or 0.645 $\times 10^{-7}$ hydrogen-ion concentration, and the range from 0.25 $\times 10^{-6}$ to 0.38 $\times 10^{-7}$.

An analysis of the water from Faagalu stream below the water-falls was made by Prof. Alexander H. Phillips, and shows a high percentage of chlorine, and bicarbonates and very little ammonia, or nitrates. The calcium, magnesium sodium and potassium are more than sufficient to hold the bicarbonates, HCO_3, in an ionic state.

The following is an abstract of Professor Phillip's analysis of Faagalu stream water.

Sample taken April 14, 1917

	Parts per million		*Parts per million*
Free Ammonia	0.036	Magnesium (Mg)	2.20
Albuminoid ammonia	0.028	Sodium (Na)	6.19
Nitrogen in nitrites	none	Potassium (K)	2.16
Nitrogen in nitrates	0.04	Bicarbonate (HCO_3)	9.60
Oxygen consumed	2.05	Sulphate (SO_4)	4.06
Total solids	70.06	Chlorine (Cl)	12.00
Silica (SiO_2)	26.55	Nitrate (NO_3)	.17
Iron(Fe_2O_3) are Alumina (Al_2O_3)	0.95	Phosphate (P_2O_5)	.026
Calcium	3.03	Hydrogen ion concentration of the water 0.5×10^{-7}.	

It is evident that the calcium is too great in proportion to the sodium to have been derived from the salt spray, and must therefore have come from the rocks or the decaying vegetation of the Island.

In Oahu, Hawaiian Islands, also, the streams are alkaline, for Dr.

C. Montague Cooke, Jr. of Honolulu, kindly transported me in his automobile to eight of the larger streams and springs, between Palolo and Monanalua valleys, and these were all alkaline, ranging from 7.1 to 8.12 PH.; the average being 7.34 PH. or 0.457×10^{-7}. The higher alkalinity of the streams of Oahu may be due to the presence of elevated limestones, these being absent from Tutuila. Thus the surface waters draining off from Tutuila, and Oahu, being alkaline, cannot dissolve limestones by reason of their 'acidity,' and the Murray-Agassiz theory of solution of the shoreward parts of reef flats by fresh water is not supported.

The openings in coral reefs opposite the mouths of streams are due to the fact that corals cannot survive and have never grown, in these places, due to silt and dilution in time of flood. This was proven at Tutuila by placing 26 specimens of 12 species of Acropora, Pavona, Psammocora, Porites, Pocillopora, Fungia, and Coeloseris, 150 feet from the mouth of Pago Pago brook in a place where the bottom is covered with fine brown volcanic mud and no corals are found. The salinity in this situation was observed to range between 31.38 to 25.48; that of the open sea about being 34.83. Yet the corals survived in this diluted water, for fifteen days, although the Acroporas did not expand. However all but one species were killed by the freshet due to the torrential shower of 4.3 inches on April 12, 1917, which reduced the salinity to 0.93, becoming only 9.25 at the end of 24 hours. All the corals died with the exception of 2 out of 3 specimens of massive *Porites* which withstood the dilution and silt but with apparent injury. This species of *Porites* lives nearer to streams mouths and closer to the shore than does any other coral of Samoa.

It is apparently uninjured by being placed for an hour in water of a constant temperature of 36° C., which would be fatal to all the *Acropora*, *Pocillopora* and dominant off-shore corals of the reefs.

On the reef flats of both Murray Island, Australia, and Tutuila, Samoa, coral heads are most densely clustered in relatively quiet water about 150 to 200 feet shoreward from the region wherein the surges die out in ordinary weather.

The greatest variety of species of corals are, however, found just where the surges die out in ordinary weather.

In both Murray Island, Australia, and Tutuila, Samoa, four genera constitute over 90% of the coral heads of the reef flats. Thus:

NAME OF CORAL	PERCENTAGE OF CORAL HEADS	
	Murray Island, Australia	Tutuila, Samoa
	per cent	*per cent*
Porites	38	47.4
Acropora	18	33.6
Pocillopora	10	4.01
Psammocora	Very rare	10.0
Serialopora	25	0.0
Totals	91	95.1

It was found that when shallow reef-flats are impounded and cut off for about an hour from the open ocean at low tide, the water quickly becomes nearly twice as alkaline in places as in the open ocean, while in other places it becomes abnormally reduced in alkalinity. The increase in alkalinity is caused by the photo-synthetic action of plant cells within the corals and by sea weeds.

Rail falling directly into the sea has far more effect in reducing the alkalinity of the surface water than has stream water pouring outward from the shore. Yet the torrential rain of 7.8 inches in about five hours on March 19 reduced the surface alkalinity only from 8.20 to 8.18 PH., and the salinity from 34.69 to 30.46 off the landing-stage of Blacklock's wharf near the inner end of Pago Pago Harbor, and the alkalinity of the harbor remained about 34.33 despite the average rainfall of more than one inch per day from January 1 to April 17.

The scouring of sand from their floors by currents is a potent factor in deepening the shoreward parts of the reef-flats, and may result in changing a fringing reef into a barrier reef. The lithothamnion ridge lying along the seaward edge withstands this process of disintegration for by growing, it resupplies such loss and maintains itself about 6 inches above low tide level. The corals growing over the shoreward parts of the reef-flats also tend to replace the lost limestone and some reefs may thus maintain themselves as fringing reefs, as at Aua, Pago Pago Harbor, while others as at Black's Bay, Tutuila, become deepened near shore so as to change into barrier reefs. At Aua the current over the reef-flat ranges from 20 to 62.8 feet per minute, and is an effective transporter of coral sand; spilling it into deep water off the northern edge of the reef. This scouring process is doubtless facilitated by the holothurians which are well known to be sand swallowers. There is on the average one of these animals for every 8.6 square feet of reef flat off Aua, Pago Pago Harbor.

It is our hope to return to Samoa in 1918 to remeasure and re-weigh corals, and thus determine their growth rate, and to bore through the coral reef, study the question of the existence or non-existence of a submerged marine platform, and evaluate the sand-carrying ability of currents over the reef flats, and of solution due to holothurians. The results may then be published by the Carnegie Institution of Washington.

It is a pleasure to express our gratitude to Hon. Josephus Daniels, Secretary of the Navy; and also to His Excellency, Governor John M. Poyer, Commander U. S. N., and his officers who did all in their power to facilitate our studies.

NATIONAL RESEARCH COUNCIL

SUGGESTIONS RELATING TO THE NEW NATIONAL ARMY BY THE ANTHROPOLOGY COMMITTEE OF THE NATIONAL RESEARCH COUNCIL

The recruiting of a large army from the diversified elements of the national population must present certain contingencies in which Physical Anthropology may be of much practical service, and at the same time should afford many opportunities by the utilization of which this and related branches of science may greatly benefit.

1. Examination of Recruits.—The examination of recruits for admission into the new Army will include certain observations which, if properly systematized and made by simple, accurate, standardized instruments, should prove of great statistical value. Unhappily the methods followed today and the instruments by which the measurements are taken lack in uniformity as well as in accuracy. Unless a few necessary improvements are made in both, the great body of data derived from the examination of a million or more men cannot be utilized by science with full confidence; and as properly revised regulations would not increase, but actually diminish the burdens of the examiners, the Committee on Anthropology takes the liberty of urging immediate consideration of the question of revision. Suggested modifications of the present examination blanks and specifications for simple outfits of instruments, together with directions for the examiners in making measurements and physical observations have already been submitted by the Committee to the National Research Council.

In this as well as in other recommendations which the Committee has made the utmost care was taken not to add to, but rather to reduce the burdens of the medical examiners and the medical service of the army. No additional tasks at this time unless of the highest practical importance would be justifiable or feasible.

2. Modification of Stature Requirements.—The present minimum requirements of stature, in any branch of the army or the navy, is 5 feet, 4 inches. In the case of mountain artillery it is 5 feet 8 inches.

The minimum for the English infantry and some other branches of the service prior to the present war was 5 feet, 2 inches, and it has since been reduced. On the Continent the minimum differs with the nationalities, but is as a rule lower than that of the United States. In many of these nationalities the average height of the adult male does not reach, barely equals, or only slightly surpasses the minimum requirement for the soldier of the United States. Many of these nationalities are well represented in this country. They include the Italians, Greeks, French, Mexicans, Spanish, Swiss, the Russian and Austrian Jews, many of the Slavs, the Magyars, Roumanians, Lithuanians, and even Germans. Should the present minimum in stature for the United States Army and Navy be rigidly adhered to, from one-fourth to one-half of the men belonging to or descending from the nationalities mentioned would be excluded by this rule alone, thus resulting in serious disadvantages, the chief among which would be that of placing a disproportionate burden in the formation of the army on the naturally taller native American.

In view of the above facts, and as small stature in a large majority of cases signifies normal fluctuation and not any weakness or degeneration, as has been repeatedly proved by the 'bantam' regiments of England and other short stature troops of European countries, the Committee recommends that the minimum stature requirement for the new United States army be reduced, for all branches of the service, to 60 or at most 62 inches; and that corresponding with this, the minimum weight requirement be reduced from 128 to 120 pounds.

3. Further Anthropometric Work for Statistical and Scientific Purposes at the Concentration Camps.—The sixteen or more concentration camps will afford a unique opportunity for anthropometric observations, one object of which would be to obtain data regarding the normal physical conditions of the American people of different descent, admixture, education, social class, occupation, and environment.

To utilize these opportunities the minimum requirement would be the selection of six of the camps representing the northeast, southeast, the northern middle states, the south, the southwest, and the northwest; and placing in each a specially trained young medical officer who would devote his time to the anthropometric work.

The investigations, reduced to the minimum, would consist of the measurement of stature and height sitting; of the three principal dimensions of the head; of two diameters of the face; of two diameters of the chest; and of more precise observations on the color of the skin, eyes, and hair than are practicable at the recruiting stations.

The training and equipment of the six medical officers would be undertaken by the Department of Anthropology of the United States National Museum.

The data procured would be elaborated without cost by the Statistical Staff of the Prudential Insurance Company of America. Publication of the results would be facilitated as far as possible by the Smithsonian Institution.

The total period of the investigations could be limited to six months if found advisable. The officers required for conducting the observations should be appointed by the medical departments of the army and the navy. Their special training at the United States National Museum would require one month.

4. Material for Future Scientific Research.—The organization of the new army will afford important opportunities for additional scientific research and the collection of data and specimens which should be utilized as far as practicable. Efforts in this direction were made in the Northern Army of the United States during the Civil War; the results are embodied in three volumes of data by Baxter and Gould, and in the collections of the Army Medical Museum. According to available information, more or less extended scientific researches are being conducted and illustrative collections made at the present time in connection with nearly all the armies of Europe.

The United States Army will include not only men of many nationalities, but also those of different races, such as Indian, Negro, Filipino, and possibly Japanese and Chinese. Even under the best hygienic conditions and without actual participation in war a certain proportion of these must be expected to become ill and die in hospitals. The bodies of such dead cannot, as in peace, be transported hundreds or thousands of miles, perhaps, to their friends, but must be cremated or buried in the vicinity of the hospitals. These bodies offer a valuable opportunity for postmortem determinations, such as the cause of death as found at autopsy, the weight of the different internal organs, etc., and also for assembling specimens which would be of the utmost value to future pathological, anatomical and anthropological investigation. The Army Medical Museum and the United States National Museum would gladly take charge of the preparation and distribution of such material.

For the above purposes it is requisite that in each of the more important hospitals one member of the medical staff, preferably a pathologist or an assistant pathologist, be designated to gather needed records and specimens; and it is earnestly recommended that such a detail be made immediately on the establishment of each large army or navy hospital.

W. H. HOLMES, *Chairman*,
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ALES HRDLICKA,
MADISON GRANT,
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NATIONAL RESEARCH COUNCIL

FIRST REPORT OF COMMITTEE ON BOTANY

The first work of this Committee was to make a census of competent investigators and of the problems under way. Botanists were also asked to suggest additional problems bearing upon public welfare, and numerous suggestions were received. In the main these are long-time problems, very important to continue, but not expected to yield immediate practical results.

When the United States entered the war, a large number of emergency problems arose. The larger number of these had to do with the available sources of plant materials and products. Many of them were questions asking for information, rather than problems needing investigation. Dr. E. M. East, a member of the Committee, was asked to take charge of this phase of the work. Finally it seemed best to establish a Special Committee on Raw Products, with Dr. East as Chairman, which is in close co-operation with the Committee on Botany. The Commercial Museum of Philadelphia, with its unusual facilities as a source of information in reference to raw products, is also working in co-operation with this Special Committee.

The number and nature of the questions in reference to forest materials and products soon made it evident that this group of problems should be provided for in a special way, and accordingly Prof. Irving W. Bailey of the Bussey Institution was asked to take charge of this phase of the work. These problems involve such an overlapping of Botany and Forestry, and many of them are of such practical importance that it has been recommended that a Sub-Committee on Forestry be organized, which shall bring into close co-operation the Forestry Service and the Committee on Botany.

Problems Undertaken.—Among the emergency problems under way, the following have progressed far enough to be encouraging.

1. Dehydration of vegetables. A method to preserve flavor.

2. Dehydration of fruits. A method being developed chiefly in the western fruit area as a measure of conservation.

3. Sources of rubber. A problem well toward solution.

4. Improvement of sugar beets. A breeding problem undertaken by several investigators and well advanced.

5. Disease-resistant cereals. A long-time problem but advanced far enough to expect that some disease-resistant strains will soon be available.

6. Drought-resistant cereals, especially corn and sorghum.

7. Native drug plants. Information in reference to native plants from which needed drugs may be obtained is in charge of Dr. Henry Kraemer of the Philadelphia College of Pharmacy. A great many medicinal plants have been suggested, but comparatively few have been tested.

8. A substitute for cotton in the manufacture of explosives. It is necessary for this substitute to consist of nearly pure cellulose, and to be easily obtainable in vast quantities.

9. The food reserves in certain plants.

Co-operation.—Co-operative relations have been established with the Committee on Agriculture of the National Research Council, the U. S. Department of Agriculture, the Botanical Division of the Carnegie Institution, research laboratories of universities, agricultural experiment stations, botanic gardens, the Council on Pharmacy and Chemistry of the American Medical Association, the Cereal Conference, and the Association of Seedsmen. The purpose of this co-operation is the exchange of information in reference to problems under way, and in reference to pressing problems that have been encountered; and also the sharing of facilities for investigation. It should be said that information in reference to problems under way is not intended as a notice of preemption, the feeling being that several attacks upon a problem may bring speedier results.

Additional Activities.—Efforts are being made to:

1. Effect contact with manufacturers who may need information as to plant materials and products, and who may not know the most speedy way of obtaining it.

2. Effect contact with farmers so that they may receive and apply the information and advice that is accumulating.

3. Make some of the results commercially available, without specially favoring any commercial organization. Some of these results would ordinarily involve patents or trade secrets.

JOHN M. COULTER, *Chairman.*

NATIONAL RESEARCH COUNCIL

MEETINGS OF THE EXECUTIVE COMMITTEE

The sixteenth meeting of the Executive Committee was held at the offices of the Council in New York City, April 4, 1917. Messrs. Chittenden, Dunn Pupin, and the Secretary were present.

The Secretary announced the appointment of Mr. Lewis B. Stillwell to the Council. It was voted that Mr. Stillwell be appointed a member of the Engineering Committee.

The Secretary also announced the appointment of Dr. Joseph S. Ames and of Dr. Hollis Godfrey to the Council; the resignation of Dr. Hale as Chairman of the Committee on Research in Educational Institutions, and the acceptance by Dr. Chittenden of that chairmanship.

Mr. Dunn reported a gift of five thousand dollars from Mr. Edward D. Adams to the Engineering Foundation.

Dr. Chittenden presented a letter from certain members of the staff of the Sheffield Scientific School, bringing up several very practical questions on the metallurgy of brass, particularly for the use of the Army and Navy. After discussion, the letter was referred to the Secretary, to take the matter up with General Crozier, and possibly with others.

The seventeenth meeting of the Executive Committee was held at the offices of the Council in Washington, April 11, 1917. Messrs. Hale, Stratton, and the Secretary were present. Dr. Walcott was consulted by telephone and approved the proceedings. There was also present Dr. MacCallum, of the Canadian Research Council.

Professor R. W. Wood, of Johns Hopkins University and Professor Arthur Gordon Webster, of Clark University, were nominated members of the Council.

A Food Committee was authorized, Dr. Hale to name the Chairman and the personnel of the Committee.

Dr. Hale announced the appointment of Professor H. H. Donaldson of the Wistar Institute, as Chairman of the Anatomy Committee. This appointment carries with it appointment to the Council.

A Committee on Psychology was authorized, Dr. Hale to name the Chairman, who will be a member of the Council.

Dr. Millikan was elected a Vice-Chairman of the Council.

The eighteenth meeting of the Executive Committee was held at the offices of the Council in Washington, April 16, 1917. Messrs. Carty, Chittenden, Conklin, Hale, Noyes, Pearl, Walcott, and the Secretary were present.

This meeting was called at the suggestion of Dr. Noyes to discuss the proposed relations of the National Research Council with the State Research Committees of Councils, which may be appointed in different states of the Union. The immediate occasion was the appointment of a State Research Committee in California. It was voted to telegraph to the State Research Committee of California, an expression of a desire to co-operate with them, and to follow this telegram with a letter of explanation.

It was voted to request the President of the National Academy of Sciences to appoint Mr. John R. Freeman, and Professor John C. Merriam members of the Council.

The action of the Military Committee in appointing a Noxious Gas Committee was approved.

An Optical Glass Committee was authorized, with Dr. Millikan as Chairman.

Mr. John R. Freeman was appointed a member of the Engineering Committee.

The nineteenth meeting of the Executive Committee was held at the offices of the Council in Washington, May 3, 1917. Messrs. Carty, Dunn, Hale, Noyes, Pupin, Stratton, and the Secretary were present.

Dr. Pupin spoke of the urgent necessity for further information on the status of the submarine detection investigation. He urged that all members of the Council who are working on the matter be informed regarding the tests which have already been made and that opportunity be given to take

part in preliminary tests, in order to learn the conditions surrounding the problem. Dr. Carty spoke of the work that the Western Electric Company and the General Electric Company are doing in connection with the Submarine Signalling Company.

The twentieth meeting of the Executive Committee was held at the offices of the Council in Washington, May 24, 1917. Messrs. Dunn, Hale, Millikan, Stratton, Vaughan and Walcott, were present. Messrs. Durand, Mendenhall and Pegram were also present upon invitation. Dr. Bogert, after election as a member of the Executive Committee, was also present.

It was decided that Dr. Millikan, in view of his position as Vice-chairman of the Council, should be regarded as an ex-officio member of the Executive Committee. The vacancy in the Committee thereby created was filled by the election of Dr. M. T. Bogert, Chairman of the Chemistry Committee.

Upon motion it was voted that all sub-committees of the Council be appointed by the Executive Committee upon recommendation of the Chairmen of Committees.

Report was made upon the present difficulty in obtaining release from England of Austrian and German scientific journals addressed to societies and individuals in the United States. The Chairman thereupon was requested to present the facts to the State Department with an expression of the desire of the National Research Council to have steps taken to secure the release and uninterrupted transmission of such periodicals, if this can be done without conflict with other obligations.

Dr. Stratton, Chairman of the Committee on Census of Research, reported progress in the distribution of Census Blanks, stating that for this purpose institutions in the United States had been classified as follows: 1. Educational; 2. Industrial; 3. Other than Educational and Industrial. The necessary expenses of the work of the Committee were considered and the Chairman further reported that within a few days the question of indexing and rendering available the information now being received would be considered.

Upon motion it was voted that the appointment of the following Mathematics Committee be confirmed, with the understanding that three additional members be added to this Committee upon nomination by the National Academy of Sciences: Professor E. H. Moore, Chairman; Messrs. E. W. Brown, F. R. Moulton, R. S. Woodward, E. B. Wilson, George D. Birkhoff.

Upon motion of Dr. Millikan the appointment of a Sub-committee on Visibility, of the Physics Committee, was confirmed. This Sub-committee consists of Dr. Herbert E. Ives, Chairman, and Mr. Irving G. Priest.

The Chairman of the Council reported that Dr. W. H. Howell had been appointed as Vice-chairman of the Physiology Committee to serve as Chairman of the Committee during the absence of Dr. Cannon.

Dr. Victor C. Vaughan, Chairman of the Committee on Medicine and Hygiene, reported that he had appointed a Sub-committee on Psychiatry

under the chairmanship of Dr. Stewart Paton, with the following membership: Messrs. Pearce Bailey, Albert M. Barrett, Henry A. Cotton, Charles L. Dana, Walter E. Fernald, Adolf Meyer, Thomas W. Salmon, Elmer E. Southard, Roy M. VanWart, William A. White. Upon motion it was voted that the appointment of this Psychiatry Committee be confirmed.

Dr. Vaughan also reported that the Secretary of the Interior has permitted Dr. Franz at St. Elizabeth's Hospital to train men for rehabilitation work. He also stated that Dr. Murlin has been asked to make observations and report upon the food and rations which are issued to soldiers in training at Plattsburg.

Upon motion it was voted that a Sub-committee on the Sterilization of Water, with Dr. Phelps as Chairman, be appointed.

Dr. Vaughan further reported that he had been asked to serve as Chairman of the Research Committee of the General Medical Board of the Council of National Defense. He stated that the Surgeon General has consented that recruits in concentration camps be examined by experts instead of by individual medical officers, involving the necessity for the appointment of an Examining Board of the Army. Upon motion it was voted that the Chairmen of the Anatomy, Psychology, Psychiatry, and other related committees, be recommended for appointment on such an Examining Board, together with Colonel Bushnell, who is already a member.

The Chairman was requested to appoint a committee to report on cooperation between the National Research Council and the Research Committees appointed by the various states. The following committee was appointed for this purpose: Dr. C. E. Mendenhall, Chairman, Messrs. Bogert, Durand, W. B. Hale, and Vaughan.

It was voted that the sum of $100 be allotted to the Psychology Committee.

Upon motion of Dr. Bogert the appointment of a Potash Committee, with Dr. J. D. Pennock, General Manager of the Solvay Process Company of Syracuse, N. Y., as Chairman, was authorized. Recommendations were submitted with regard to the membership of this committee.

The Chairman of the Council read a letter from Dr. Ames, Chairman of the Foreign Service Committee, and reported upon the activities and recommendations of this committee.

The Chairman of the Council reported the organization and appointment of a special New York Committee on Submarine Warfare, the Chairman of which is Dr. Nicholas Murray Butler, and the Executive Secretary, Dr. G. B. Pegram of Columbia University. Upon motion, this action was approved and confirmed.

The suggestion was made that the letterhead of the Council be changed to read "National Research Council, Acting as the Department of Science and Research of the Council of National Defense." This question was referred to the Chairman of the Council with power.

The Chairman reported the resignation of Mr. Tod Ford as Assistant Secretary of the Council, due to his acceptance as a member of the Lafayette Squadron in France. Mr. Dunn reported the election of Mr. Walter M. Gilbert as Assistant Secretary of the Engineering Foundation and that the Carnegie Institution of Washington had courteously detailed him for such work. Mr. Gilbert was thereupon elected as Assistant Secretary of the National Research Council.

Upon motion it was voted, subject to change, that subsequent meetings of the Executive Committee be held weekly on Thursday at 9 a.m.

The twenty-first meeting of the Executive Committee was held at the offices of the Council in Washington, May 28, 1917. In the absence of the Chairman of the Executive Committee, the meeting was called to order by the Chairman of the Council. Messrs. Hale, Millikan, Stratton, Vaughan, Walcott, and Welch were present. Mr. Manning, Chairman of the Noxious Gas Committee, and Messrs. Mendenhall and Durand were also present upon invitation.

Mr. Manning read a report of the Noxious Gas Committee, making recommendations for the establishment of a laboratory for the study of problems related to this subject.

Dr. Millikan presented a report of the Optical Glass Committee, stating that recommendations had been made to the General Munitions Board, had received its approval, and in turn had been recommended to the Council of National Defense.

Upon motion of Dr. Walcott the action of the Optical Glass Committee was approved and confirmed.

The Chairman of the Council stated that a French Scientific Mission would soon reach the United States and a discussion followed regarding its reception and means for its entertainment.

The twenty-second meeting of the Executive Committee was held at the offices of the Council in Washington, May 31, 1917. In the absence of the Chairman of the Committee, the meeting was called to order by the Vice-Chairman (Dr. Millikan) of the Council. Messrs. Bogert, Chittenden, Millikan, Pearl, Pupin, Walcott, and Welch were present. Messrs. Durand and Mendenhall were also present by invitation. Dr. Hale entered the meeting before its close.

The Vice-Chairman (Dr. Millikan) of the Council reported:

That a sum of $5000 has been donated by Mr. Cleveland H. Dodge for the general purposes of the Council. and that an additional sum of $100 has been received from another source; and that these funds have been placed in the hands of the Treasurer of the National Academy of Sciences for the use of the Council.

That the President of the National Academy of Sciences has appointed the following additional members of the Council:

Dr. ARTHUR L. DAY, Geophysical Laboratory, Washington, D. C.
Professor CHARLES E. MENDENHALL, Munsey Building, Washington, D. C.
Mr. F. H. NEWELL, University of Illinois, Urbana, Illinois.
Dr. STEWART PATON, Princeton, New Jersey.

After discussion, upon motion, it was

RESOLVED, That all bills for services, supplies, and incidental expenses pertaining to the work of the National Research Council be approved by the Chairman or by a Vice-Chairman of the Council and forwarded to the Treasurer of the National Academy of Sciences or to the Engineering Foundation for payment from funds available for the use of the Council.

Upon motion it was also voted that similar approval be, and hereby is, given for the payment of bills from funds which may be available for the use of the Council at any time through any other organization.

The Vice-Chairman read a letter from the Chairman of the Chemistry Committee with respect to the advisability of the appointment of a Sub-Committee on the Chemistry of Forest Products. Upon motion, Dr. John E. Teeple was appointed Chairman of such a Committee.

The Chairman of the Council suggested that it may become advisable to appoint a special committee on nautical instruments. Upon motion, the Chairman was authorized to appoint such a committee if it may prove advisable to do so after consultation with members of the General Munitions Board and of the Shipping Board.

It was decided upon motion, to have embossed the new letterhead to be used on stationery for the general offices of the Council and for its committees. The appointment of a special committee to consider other questions of detail with respect to the office business of the Council, was approved.

The twenty-third meeting of the Executive Committee was held at the offices of the Council in Washington, June 21, 1917, and was called to order by the Chairman of the Council. Messrs. Bogert, Hale and Stratton were present. Messrs. Durand and Mendenhall were also present upon invitation.

The Chairman reported:

That Mr. Edward D. Adams has donated the sum of $5000 to the Engineering Foundation for the use of the National Research Council.

That Mr. Martin A. Ryerson has donated the sum of $1000 for the use of the Council and this sum has been deposited to the credit of the Council in the Riggs National Bank, Washington.

That the Carnegie Corporation of New York at its meeting of June 4, 1917 authorized a grant of $50,000 to the Carnegie Institution of Washington for purposes of the National Research Council, with the understanding that disbursements on account of this donation will be made at the discretion of the President of the Institution.

That Dr. Day, Mr. Mendenhall, Mr. Newell, and Dr. Paton have accepted appointment as members of the Council.

That at the request of the General Munitions Board, a special Committee on Navigation and Nautical Instruments has been appointed with Dr. L. A. Bauer, Director of the

Department of Terrestrial Magnetism of the Carnegie Institution of Washington, as Chairman, and the following as additional members:

Commander J. S. DODDRIDGE, U. S. Naval Observatory, representing the Bureau of Navigation.

Mr. ROY Y. FERNER, representing the U. S. Bureau of Standards.

Mr. R. L. FARIS, representing the U. S. Coast and Geodetic Survey.

It is probable that other members of the Committee will be appointed. Upon motion it was then

RESOLVED, That the Executive Committee of the National Research Council desires to express to the trustees of the Carnegie Corporation of New York its appreciation of the generous and timely assistance which has been provided for purposes of the Council by means of an appropriation of $50,000 to the Carnegie Institution of Washington to be disbursed through said Institution for such purposes.

Consideration was given to the question of the organization of the Council, and of representation in its membership of various scientific activities. Upon motion, the Chairman was requested to appoint a special committee to consider all such questions and report thereon at a subsequent meeting of the Committee. Dr. Bogert was named as the Chairman of this Special Committee and requested to confer with the Chairman of the Council with regard to its membership.

The Chairman presented letters from the Chairman of the Botany Committee and from Dr. E. M. East of the Bussey Institution relative to the appointment of a special committee on Botanical Raw Products. He also presented a letter from Dr. Earle H. Clapp, Chairman of the Committee on American Forest Research of the Society of American Foresters, urging the appointment of a special committee on forestry. After discussion, the Special Committee of the Council on Organization and Representation, of which Dr. Bogert has been appointed Chairman, was requested to give early consideration to questions raised by the suggestions and recommendations just submitted, with particular reference to the relation of work on forest products to other activities of the Council.

Upon recommendation of the Chairman of the Anthropology Committee, Dr. Charles B. Davenport, Cold Spring Harbor, New York, was appointed a member of this Committee in place of Dr. Tom A. Williams, who has been detailed for foreign service.

Dr. Mendenhall submitted the following report of the Committee of the Council appointed to consider questions of relations to State Councils of Defense:

The Committee appointed to consider the question of the organization of state research committees and their relation to the National Research Council reports as follows:

In the opinion of the Committee the matter of the usefulness and value of state research committees is in the experimental stage at present, so that it is undesirable for the National Research Council to take the positive attitude of urging the formation of such committees. It seems best to allow developments to take place in accordance with local needs, but to take

the precaution of outlining a form of procedure to recommend to the state councils of defense in case the organization of research committees is decided upon.

The Committee therefore recommends that a letter be sent to the proper officer of all the state councils of defense which have not already organized research committees, embodying the points considered below, and that a letter offering the complete co-operation and assistance of the National Research Council be sent to those state councils which have already organized research committees.

The National Research Council has carefully considered the question of the general organization of State Committees or Councils of Research, and has come to the conclusion that such organization should be determined by local needs and conditions. Local causes, such as the development or investigation of natural resources or the proper development of the use of research methods in industries, or the correlation of industries with research laboratories already existing at educational institutions, may make it very desirable to organize such state research committees. In fact, the present emergency offers, in some respects, an unusual opportunity for improving the correlation of industry and research, and it is highly desirable that those concerned with this development should not only consider it with reference to the emergency but should also plan for the permanent continuance of any research committees which may be formed.

If such a committee is decided upon, the National Research Council is desirous of co-operating in every possible way and suggests the following scheme of organization: Committees should be organized under the State Council of Defense (or similar official body) and at least their general expenses provided for by the state: they should be representative of the universities and other leading educational institutions through members chosen from their scientific and engineering research departments and also of those industries in which applied science plays the most important part. In choosing the personnel of the Committee in accordance with this general scheme, it is recommended that it include some representation from the committees on research of the universities of the state. Such a State Research Committee would be chiefly active through subcommittees assigned to consider particular questions, but should have a permanent secretary to handle correspondence and through whom close contact could be maintained with the National Research Council.

Upon motion, this report was adopted, and the recommendations contained therein approved.

CARY T. HUTCHINSON, *Secretary.*

NOTICES OF BIOGRAPHICAL MEMOIRS

The following biographical memoirs has been published by the Academy since the last notices of such memoirs appeared in the December, 1916, number of the PROCEEDINGS.

ALFRED MARSHALL MAYER (1836–1897). By ALFRED G. MAYER and ROBERT S. WOODWARD. *Biographical Memoirs of the National Academy*, **8**, pp. 243–272.

This Memoir follows the life-work of Alfred M. Mayer according to the outline: Ancestry, Early Self-education, Friendship with Joseph Henry, Successive College Positions, varied scientific interests and publications, 'Mayer's Law for Human Audition', Interest in Natural History, Magnetic Studies, Foreign Visits, Inactive Middle Period, and Fruitful Close of Life. A bibliography of 76 titles concludes the Memoir.

EDWARD SINGLETON HOLDEN (1846–1914). By W. W. CAMPBELL. *Biographical Memoirs of the National Academy*, **8**, pp. 347–372.

This Memoir recounts the life-work of Edward S. Holden: Early Education, West Point and Army Service, Appointment at the U. S. Naval Observatory, the Great Nebula in Orion, Popular Articles and Textbooks, Librarian in U. S. Naval Observatory, Work at the University of Wisconsin, Solar Eclipse of May 6, 1883, Transfer to the Lick Observatory, and Up-building of its Staff, Photography of the Moon, Librarian of the U. S. Military Academy at West Point. The numerous titles of his contributions cover 15 pages.